



# **Advanced Compton Telescope**

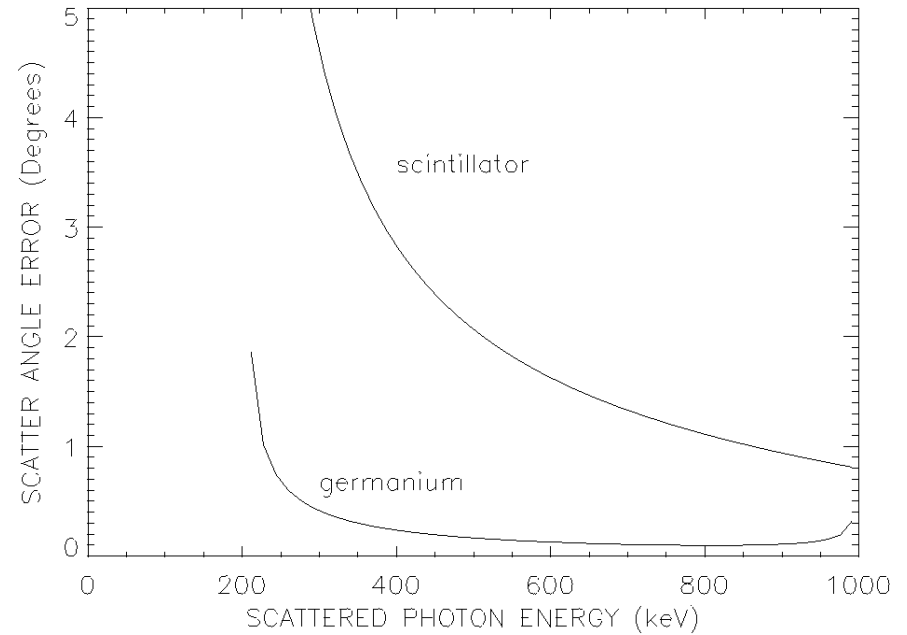
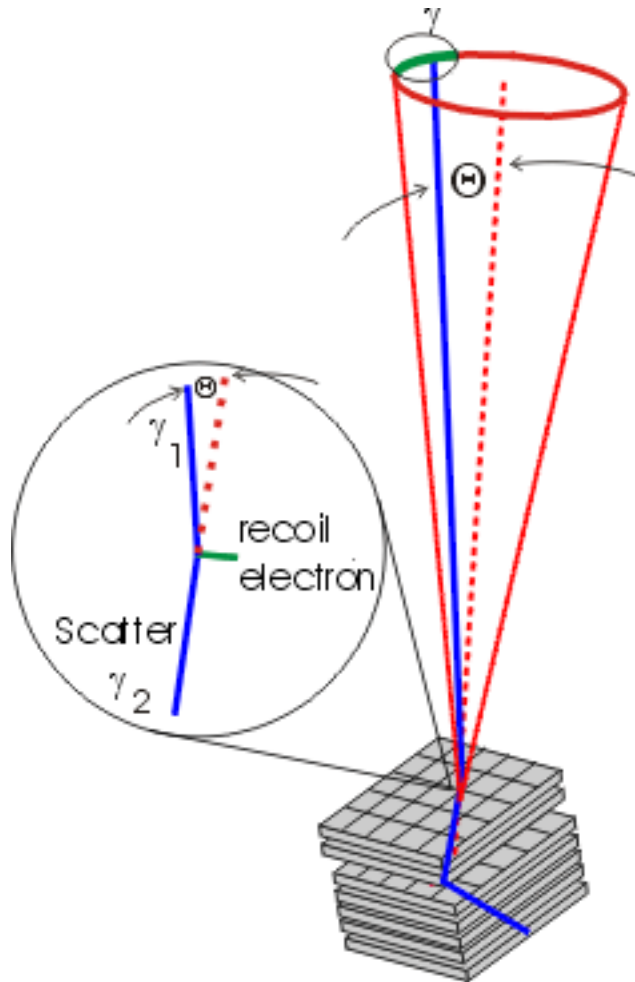
## **3-Compton w/semiconducting detectors**

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Naval Research Laboratory





# Compton Scattering



$$\cos \phi = 1 - m_e c^2 \left[ \frac{1}{E_2} - \frac{1}{E_1} \right]$$

$$\delta \phi = \frac{m_e c^2}{\sin \phi} \left[ \frac{\delta E_u^2}{E_1^4} + \delta E_l^2 \left[ \frac{1}{E_2^2} - \frac{1}{E_1^2} \right]^2 \right]^{\frac{1}{2}}$$



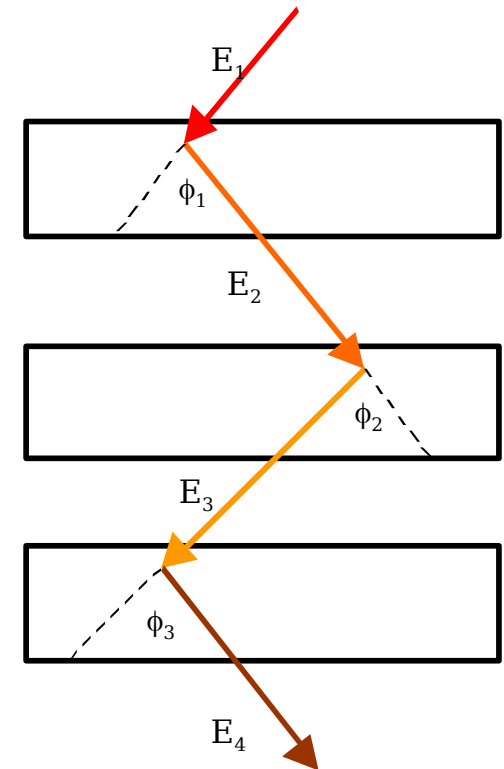
## Three Gamma Interaction Technique

$$\cos\phi_1 = 1 - m_e c^2 \left| \frac{1}{E_2} - \frac{1}{E_1} \right|; \quad L_1 = E_1 - E_2$$

$$\cos\phi_2 = 1 - m_e c^2 \left| \frac{1}{E_3} - \frac{1}{E_2} \right|; \quad L_2 = E_2 - E_3$$

$$\cos\phi_3 = 1 - m_e c^2 \left| \frac{1}{E_4} - \frac{1}{E_3} \right|; \quad L_3 = E_3 - E_4$$

$$E_1 = L_1 + \frac{L_2 + \sqrt{L_2^2 + \frac{4m_e c^2 L_2}{1 - \cos\phi_2}}}{2}$$

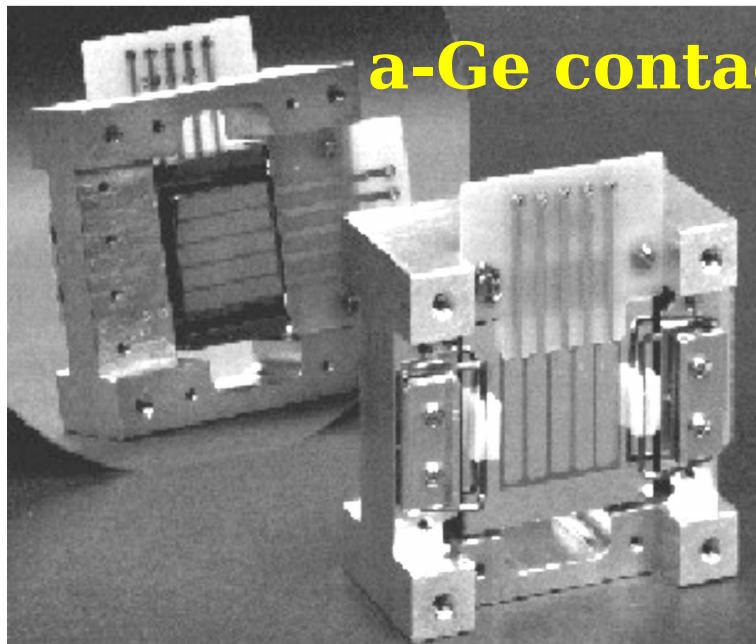


Incident gamma ray energy determined with partial energy loss

- Only three interactions required
- Dramatic improvement in efficiency
- New alternative: Silicon only Compton telescope



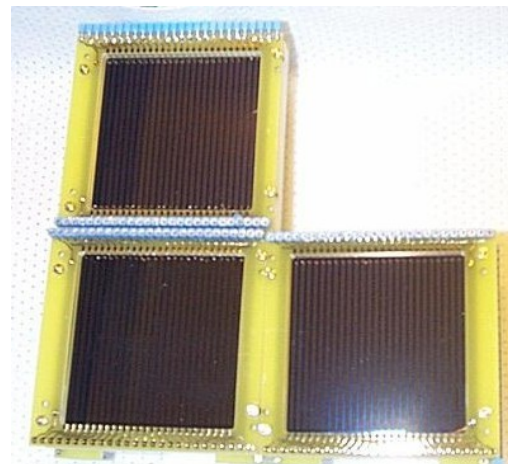
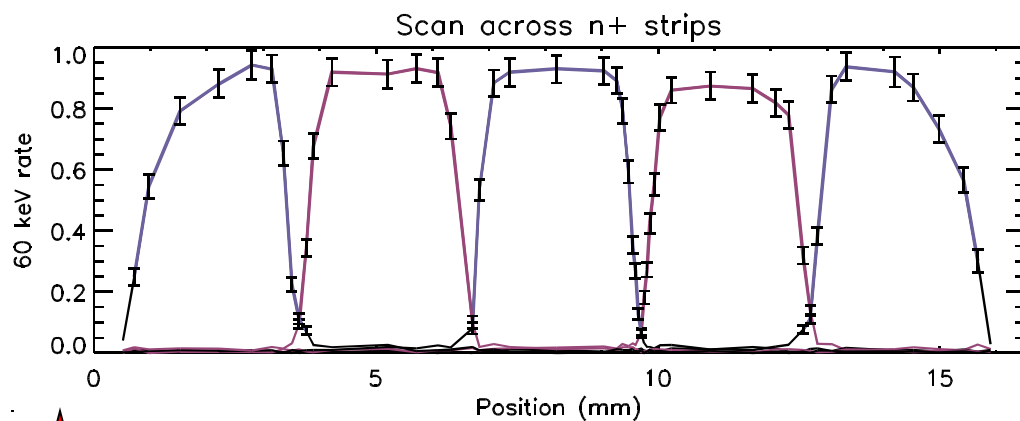
## New Germanium Technology



a-Ge contacts



Detector arrays



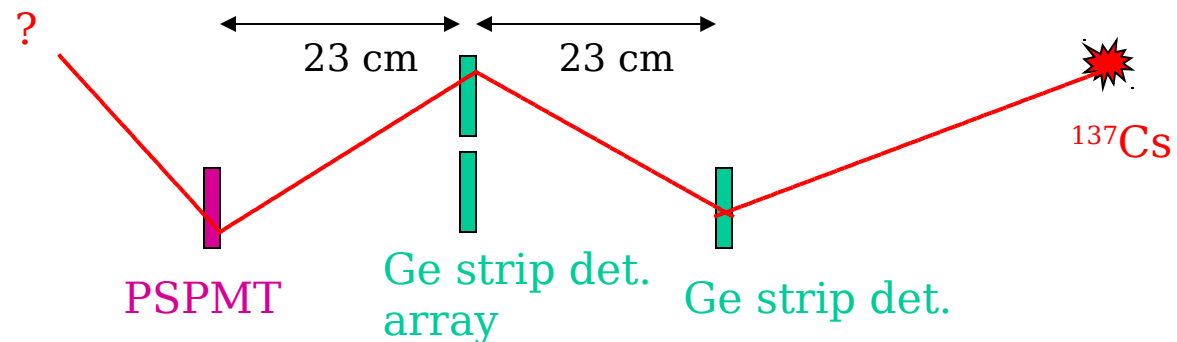
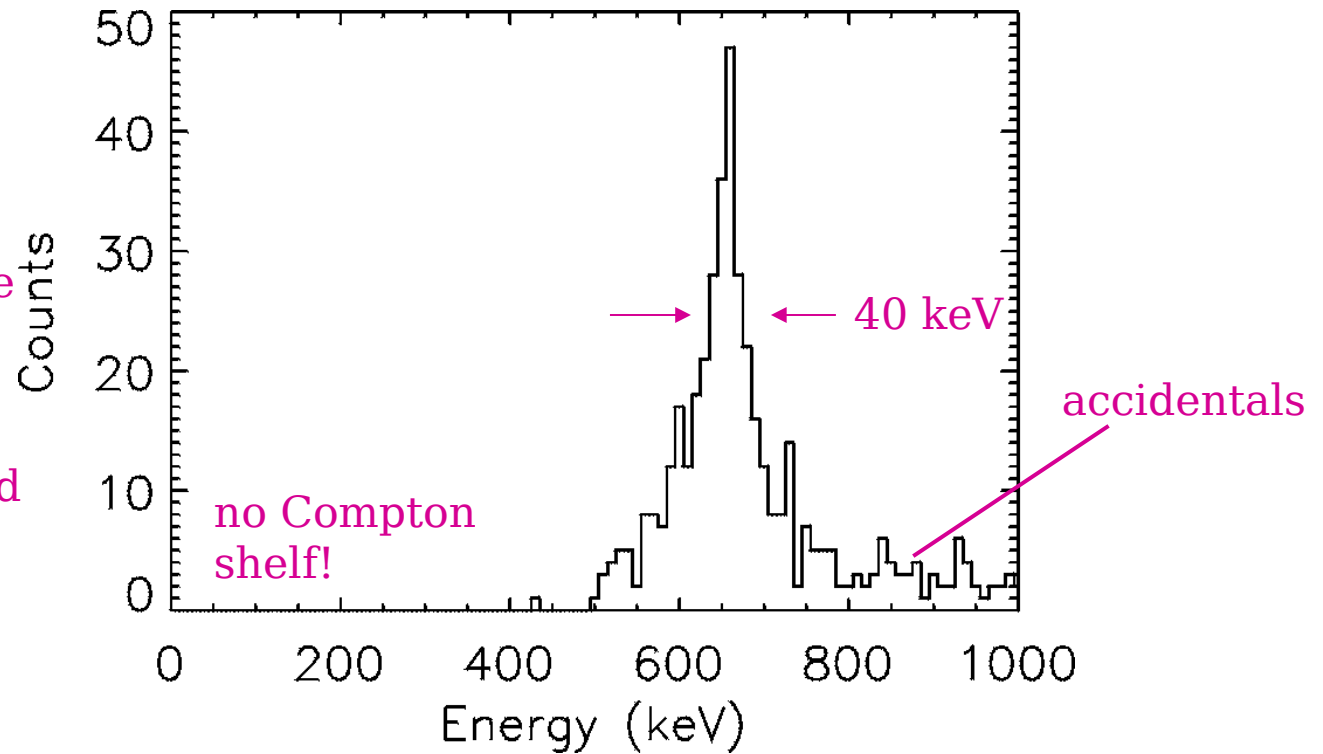


## Laboratory measurement

True 3-Compton  
measurement

Knowledge of source  
position and energy  
**not** used

PSPMT positions and  
metrology need  
improvement





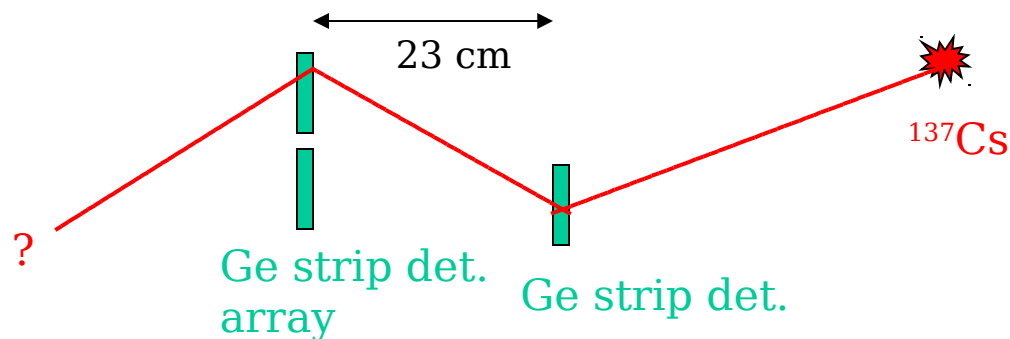
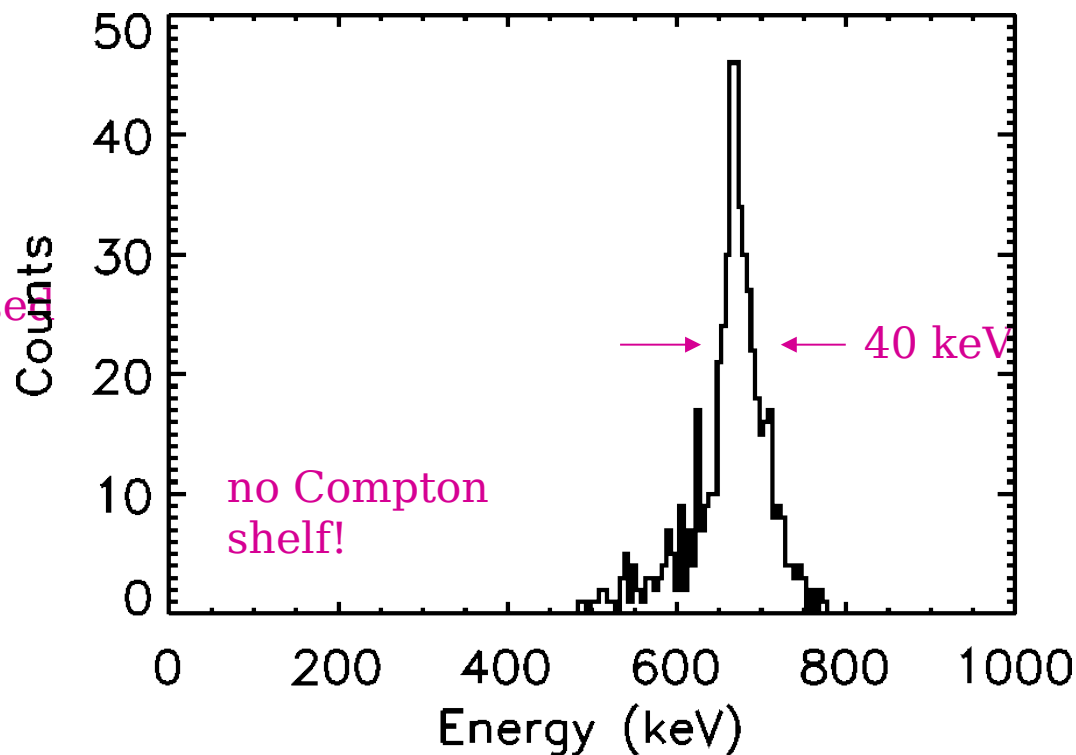
## Laboratory measurement

3-Compton  
measurement

Source position used  
to determine  
energy

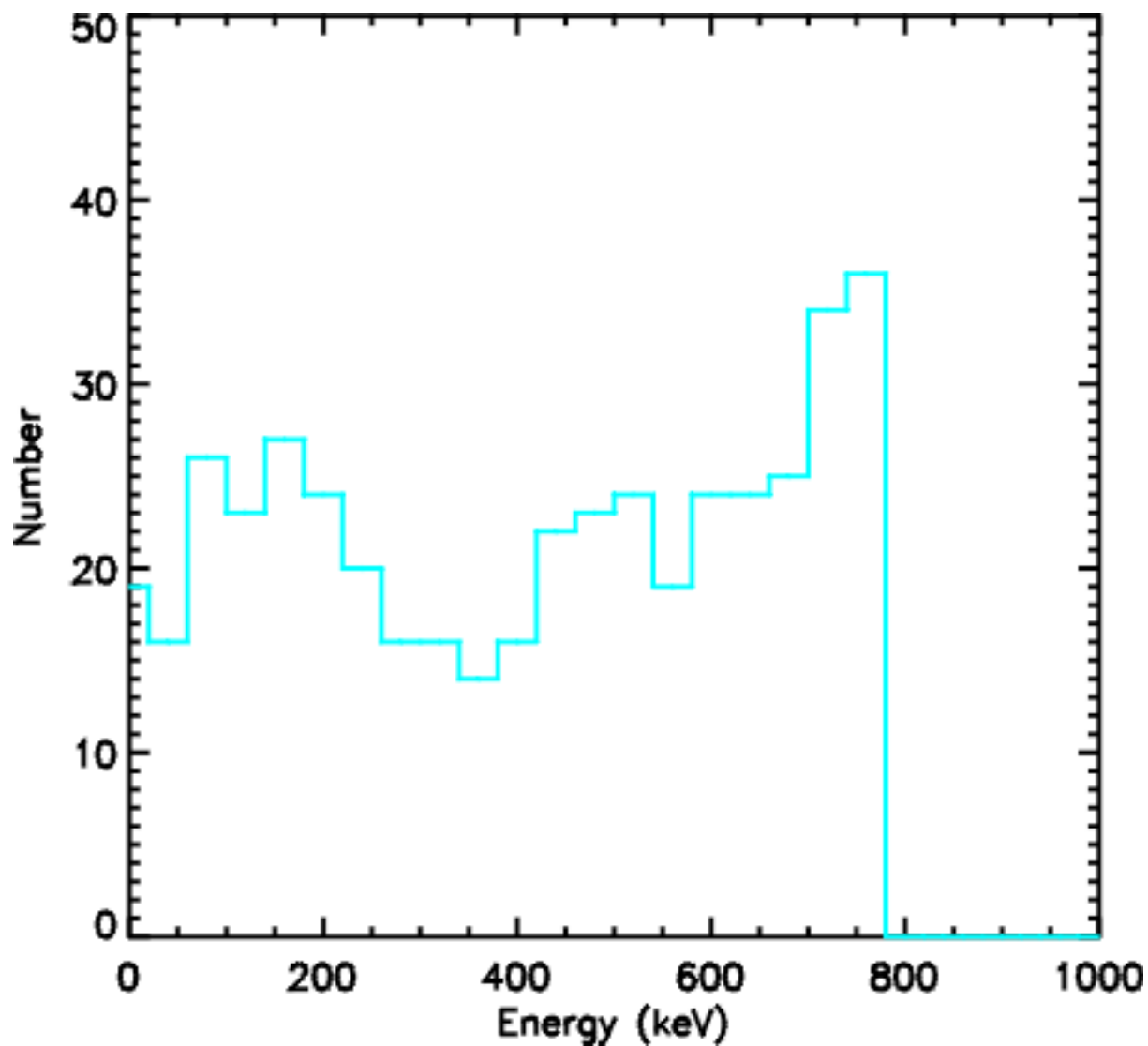
NO PSPMT

Metrology needs  
improvement



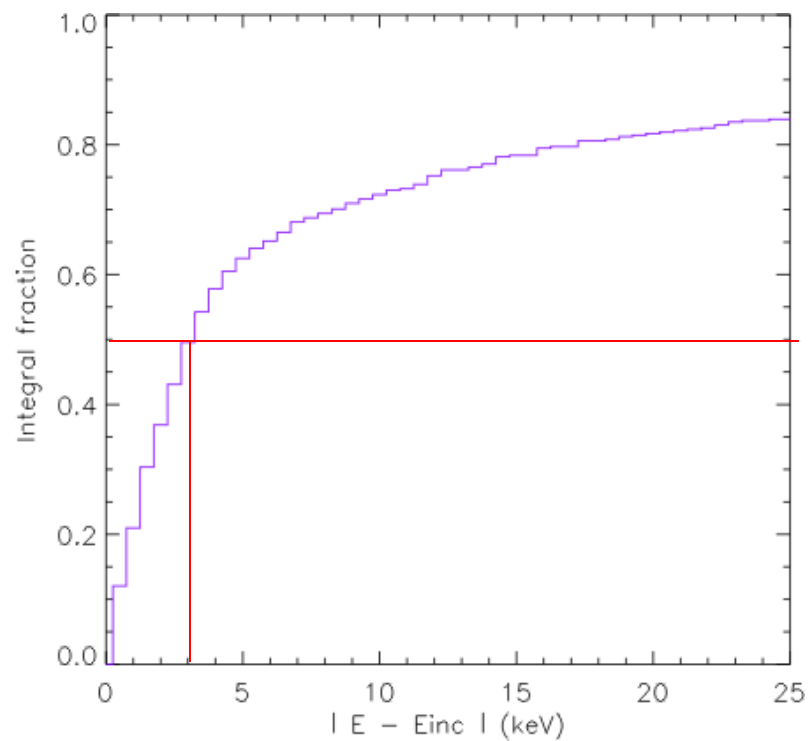
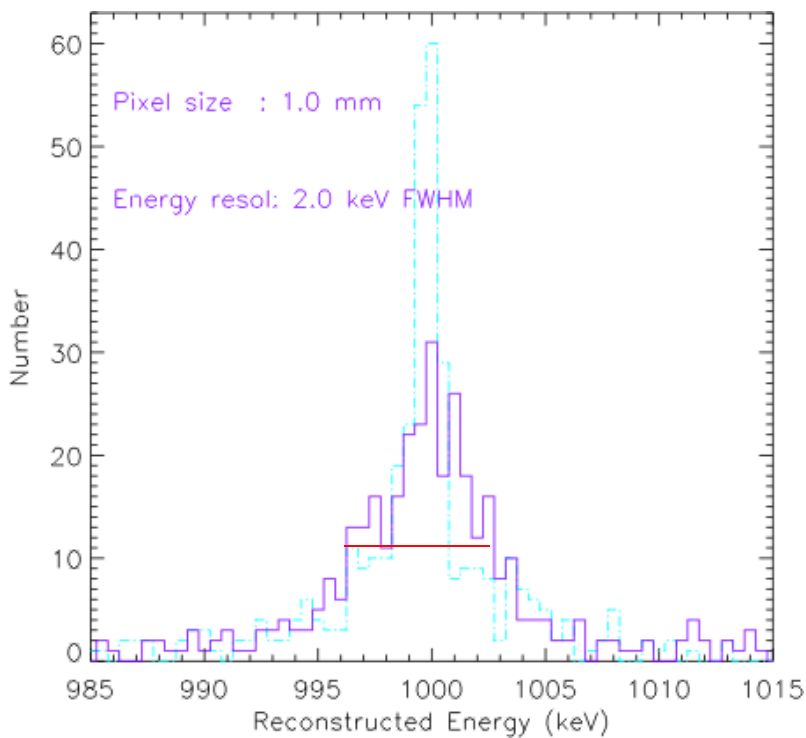


## *1 MeV in Silicon ?*





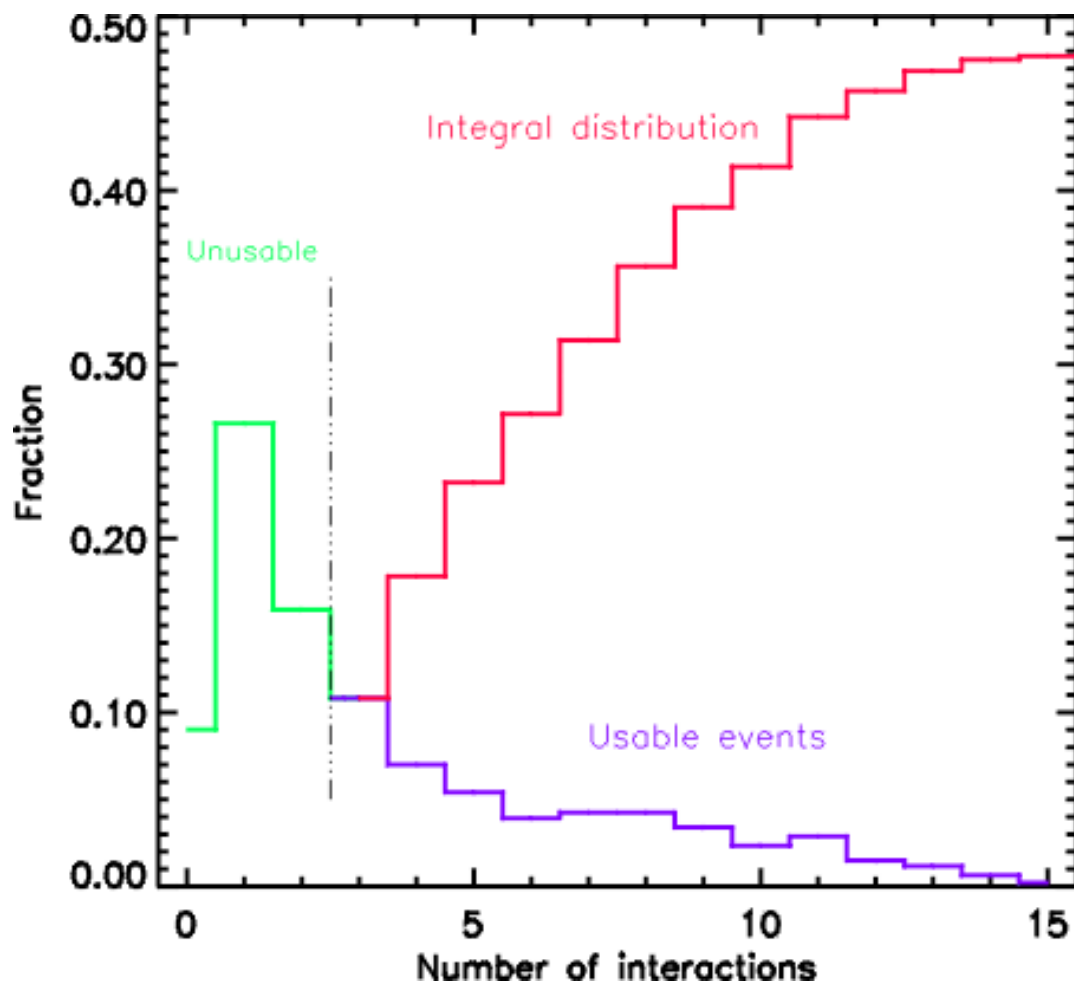
## Energy Spectra (1 MeV)





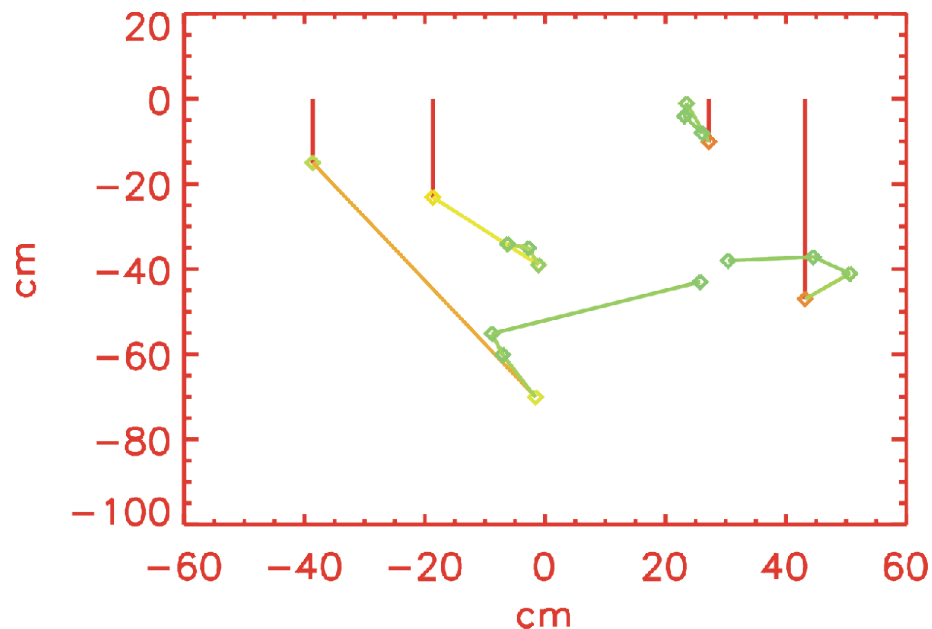


## 3-Compton Efficiency

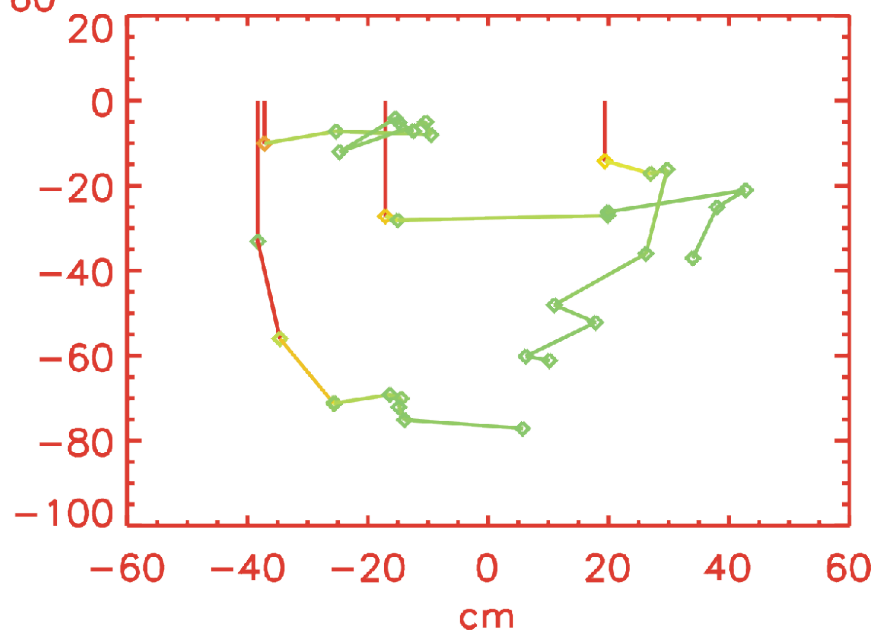




## Event reconstruction



9 interactions

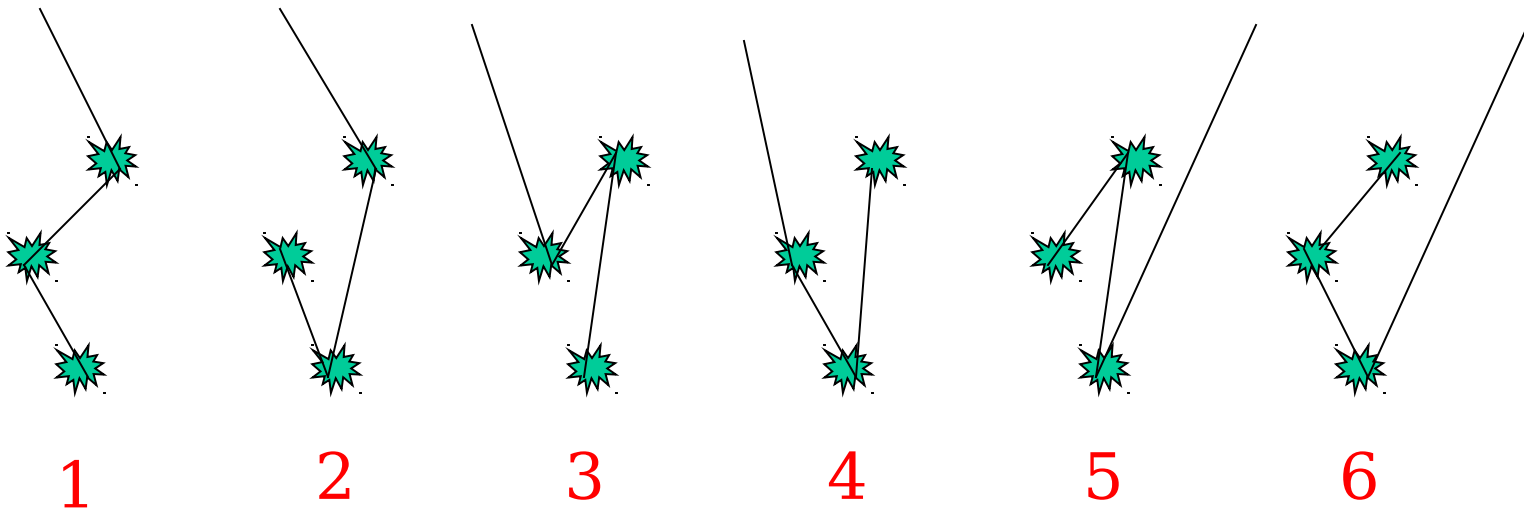




## Event reconstruction

What is the correct sequence of interactions?

- Consider events with 3 interactions
- There are **six** possible sequences
- Let's just try them all and see which ones work

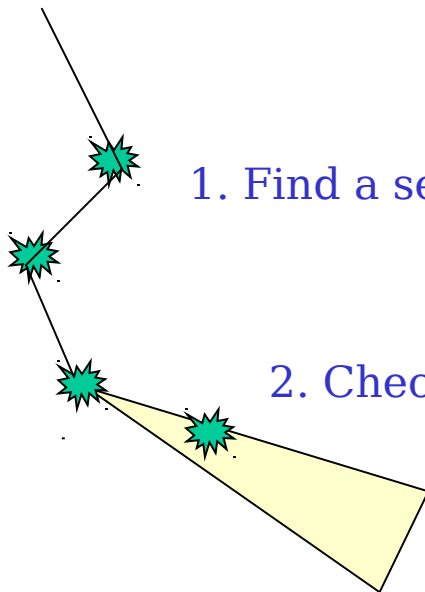




# Event reconstruction

## Events with 4 or more interactions

- Number of interactions 4      5      6      7      more
- Number of sequences 24      120      720      5040      lots more



1. Find a sequence of 3 that works

2. Check that the 4<sup>th</sup> interaction is possible

3. Repeat process for all possible sequences

4. Easily generalizes to 5 or more interactions





## Event reconstruction



### Three interactions

*How many valid solutions?*

One	12%
Two	43%
Three	41%
Four	4%

*(average 2.4)*

### We know more:

The **first** interaction was the **largest energy loss** in **60%** of the events.

### Four interactions

*How many valid solutions?*

Zero	7%	close events
One	75%	
Two	12%	
Three	2%	
Four	4%	

### We know more:

The **first** interaction was the **largest energy loss** in **63%** of the events.

